

12. *The PRECAMBRIAN (ARCHÆAN) ROCKS of SHROPSHIRE. Part II.*  
By C. CALLAWAY, Esq., M.A., D.Sc. Lond., F.G.S. *With NOTES*  
*on the MICROSCOPIC STRUCTURE of some of the ROCKS*, by Prof.  
T. G. BONNEY, M.A., F.R.S., Sec.G.S. (Read December 21,  
1881.)

IN 1879\*, I announced to the Society that the volcanic rocks of the Wrekin, originally supposed to be "greenstone," and which had recently been described by Mr. S. Allport† as bedded lavas and ashes, were Precambrian, and I showed that rocks of the same age, associated with gneissic strata of still higher antiquity, formed a chain of hills nearly thirty miles in length. In the following year, in a paper‡ "On a second Precambrian group in the Malvern Hills," I sketched the history of the physical changes which the Shropshire range, in common with the Malvern chain, had undergone, and I correlated the Salopian gneissic and volcanic series respectively with the metamorphic axis of Malvern and the felspathic mass east of the Herefordshire Beacon. Further attempts at correlation have not led to decisive results; but it is indubitable that there are strong lithological analogies between the Wrekin series and the Archæan rocks south of Bangor, as well as between the Lilleshall group and the Charnwood and St.-David's volcanic series. My present object is to describe a second area of Archæan rocks lying further to the west, and in so doing to present additional evidence of the Precambrian age of the whole group.

a. *General Description of the western Archæan Axis of Shropshire.*

The rocks of this area are exposed at intervals along a line which runs roughly parallel to the Wrekin and Caer-Caradoc chain, at a distance of from 6 to 7 miles, the strip of country which lies between being chiefly occupied by the Longmynd group. Looking at the Survey Map, it will be seen that down the valley between the Longmynd and the quartzite ridge of the Stiper Stones is drawn the boundary between the Longmynd series and the formation which Sir R. I. Murchison and the Survey described as Lingula Flags, but which by its fossils is proved to be the equivalent of the Shineton Shales (Tremadoc). At intervals along this line are put in patches of "greenstone," most of which prove to be Archæan rocks of varied character; but occasionally the Archæans appear at spots coloured as Cambrian (Longmynd). From this ancient axis the Longmynd rocks and the Tremadoc are thrown off in opposite directions. From the most northerly exposure of the Archæan, near Pontesbury, to the southern end of the chain, near Linley Hall, the distance is about 11 miles. Usually the old rocks form low hills or ridges

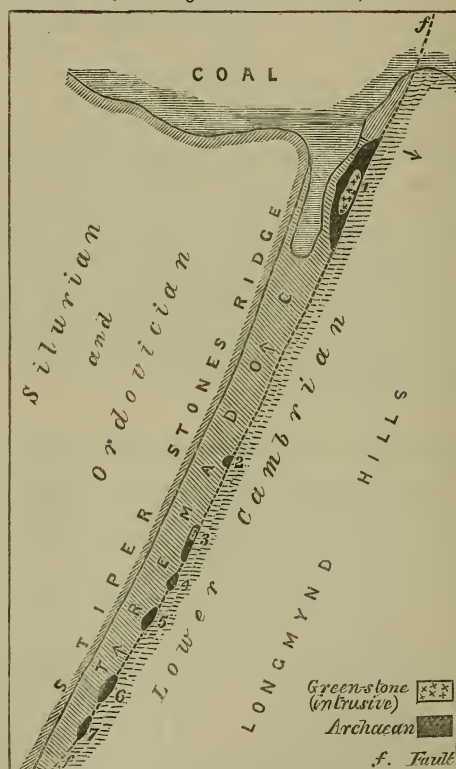
\* Quart. Journ. Geol. Soc. vol. xxxv. p. 643.

† *Ibid.* vol. xxxiii. p. 449.

‡ *Ibid.* vol. xxxvi. p. 536.

trending to the south-south-west, which are generally inconspicuous owing to the greater height of the parallel ranges of the Longmynd and the Stiper Stones on either side; but Pontesford Hill, which is partly Archæan, projects into the plain surrounding Shrewsbury as a prominent outlier from the mountain district of western Shropshire, corresponding geographically, as it does geologically, to the Wrekin in the eastern chain. The position and relations of the masses of Archæan rock exposed along the axis are shown in the accompanying map. Some of the boundaries are necessarily approximations.

*Sketch Map of the Western Archæan axis of Shropshire.*  
(Scale,  $\frac{1}{3}$  inch to a mile.)



Microscopic notes on some of the principal rock types are kindly furnished by Prof. Bonney, F.R.S. It is very satisfactory to be able to state that his conclusions, formed upon slides alone, agree precisely with my field-determinations.

b. *Detailed Geology of the Axis.*

1\*. *Pontesford Hill.*—This elevation is about one mile in length

\* This and the following numbers (1-7) correspond to the numbers in the map.

from north to south, and is coloured on the Survey Map as "greenstone." At the north end, there are good exposures of purple rhyolite, banded and spherulitic (no. 56, p. 124). The resemblance of this rock to the Wrekin lavas, and especially to the type at Lea Rock, near Wrockwardine, is unmistakable. In the quarry below the road, there is apparent bedding with a south-west dip and some contortion. Above the road, a highly spherulitic variety is well seen in the hill-slope. The spherules are frequently of chalcedony. Similar concretions, together with a smaller proportion of agate, are found as derived fragments in the Lower Cambrian conglomerates of Haughmond Hill, near Shrewsbury. A little higher than the spherulitic type, the rhyolite is clearly banded, the flow-lines dipping to the south-south-west at  $45^{\circ}$ .

The summit of the northern spur of the hill is occupied by compact dolerite (basalt) (no. 57, p. 124); and similar rock is to be traced along the ridge to the top of the mountain. This mass is apparently intrusive; and as it is not found in the neighbouring Cambrian conglomerates, it is probably Postcambrian. Doleritic rocks, some highly altered, are also exposed on the western slope of the ridge. On this side of the hill I also noticed compact felsite and hornstone of ordinary Archæan types.

The structure just described, a plagioclinal ridge broken through by intrusive greenstone, agrees with the formation of the Wrekin, the Lawley, Caer Caradoc, and other elevations of the eastern axis.

At Lyd's Hole, a picturesque ravine, with a cascade, situated about half a mile east of the north end of the hill, the purple rhyolites (no. 55, p. 124), banded and highly spherulitic, are finely exposed in the crags overhanging the stream. The flow-lines dip south-easterly at  $80^{\circ}$ . Just above the fall is a junction of the Archæans with purple sandstones and shales of Lower Cambrian age, which dip as if in conformable succession. I believe, however, for reasons which cannot here be enumerated, that the two groups are faulted together, so that the conformity of dip is merely a coincidence. Following up the stream to the south-east, we pass over several hundred feet of the Cambrian; and west of Ratcliff we come to a conglomerate dipping at a high angle to south-south-east. Pebbles of quartzite and purple rhyolite predominate; but green slate and mica-schist also occur. A little higher in the series, there is a second conglomerate, dipping at a lower angle, from  $50^{\circ}$  to  $60^{\circ}$ . The composition is similar; but the pebbles are larger, some of them reaching the size of a child's head. The purple felsite of this conglomerate is very characteristic, and is undoubtedly derived from the Archæan volcanic group.

A short distance north of Lyd's Hole, there occur stream-sections of greenish shale containing *Trinucleus concentricus*, *Orthis testudinaria*, *Diplograptus pristis*, and *Beyrichia complicata*, an assemblage characteristic of the Harnage Shales (Lower Caradoc), with which these rocks agree also in their lithology. In Murchison's 'Silurian System' it is stated that at this spot intrusive "greenstone" has "caught up fragments of shale," a singular reversal of the true facts.

There is no intrusive rock near; but pebbles of rhyolite (no. 58, p. 124) are contained in the shale. Some of the rhyolite is banded; and these enclosures are, I believe, derived from the Archæan.

In a field to the north-east of the Caradoc shale is a small exposure of micaceo-arenaceous flags of a dark grey colour, dipping south by a little east, and probably belonging to the Arenig series.

I have called attention to these detached fragments, occurring on the strike of the Tremadoc shales, as indicating the powerful dislocations which have ruptured the rocks along this Archæan axis.

2. *Gatten Lodge*.—Following the axis in a southerly direction, we come, in about three miles, to a small elevation near Gatten Lodge. Rock is exposed in a quarry near the road, with an apparent dip to the north-east. The prevailing type (no. 59, p. 125) is purplish and compact, resembling the flinty hornstone-like rock so common in the Pebedian. In places it is brecciated, the fragments, some of which are subangular, being of quartz and the purple hornstone.

3. *Knolls Ridge*.—The next Archæan mass occupies part of a ridge which I have named from a house at its north end, lying a mile and a half south-south-west of Gatten Lodge. It is about one mile long, striking with the axis. The rocks of which it is composed are varied and generally difficult of determination. Some are intrusive. At the north end is a greenstone allied to diorite (no. 60, p. 125). Felsitic rocks occur further along the ridge. At the south end is a purplish hornstone, similar to the Gatten-Lodge type.

4. *Cold Hill*.—West-north-west of the farm of Cold Hill, on the line of fault continuous with Knolls Ridge, there is a slight exposure of purple hornstone and breccia.

5. *Chittol*.—In this hill, about a mile from the last locality, is found a greenish compact rock, which I believe to be sedimentary. It has the splintery fracture characteristic of the hornstone-like rocks of the Pebedian, to which it is probably to be referred.

6. *Knolls Wood*.—This locality is a mile further to the south-south-west. The rock is hard and compact, and on fractured surfaces looks like a quartz-felsite; but where weathered it is seen to be elastic, bits of quartz and of a reddish granitoid rock being clearly visible. The latter variety is not unlike the (presumed) Dimetian of the eastern axis. Some of the fragments display a foliated structure. Altered grits similar to this rock occur in the Caer-Caradoc chain; and as the strikes in both localities are the same (east and west), and if produced would coincide, it is probable that the rocks of Knolls Wood occupy about the same horizon as those of Caer Caradoc.

7. *Ridge west of Linley Hall*.—This elevation, one mile from the last locality, forms the termination to the south of the western Archæan chain of ridges. It is composed mainly of hornstone or hälleflinta (no. 61, p. 125), purple and green, which does not quite so closely resemble the hornstone previously described as it resembles certain varieties in the Wrekin, Lilleshall Hill, and the Malverns. The Archæan is broken through by dolerite.

The purple conglomerate east of Pontesford Hill, in its course



southward, approaches more and more closely to the Archæan axis; and at Knolls Ridge and Cold Hill it is almost in contact. This is one evidence of the want of conformity previously suggested. The conglomerate does not materially vary towards the south, being still composed of quartzite and purple felsite, and nowhere containing, so far as I have observed, fragments derived from the hornstone. This is not what we should expect if, as might at first be inferred, the conglomerate were the base of the Cambrian, and formed as a shore-deposit along the Archæan axis.

I have stated that the strike of the Archæan, wherever observed, except at Lyd's Hole, is east and west or south-east and north-west, while the adjoining Cambrians, Upper and Lower, strike south-south-west, the great fault and the Archæan ridges also trending in the same direction. The formation of the fault and the upthrust of the Archæans would therefore seem to be connected with the forces which at the close of the Ordovician epoch threw the Ordovician and Cambrian deposits into folds, and determined the direction of the older mountain ridges of Shropshire. I cannot, however, speak positively on this point, since powerful earth-movements have taken place in this district along the same lines at different epochs.

It will have been noted that, as is so frequently the case with Archæan elevations, the structure of the ridges described is plagioclinal.

### *Summary of Results.*

1. On a south-south-west line running between Pontesbury and Linley Hall are seven distinct elevations, composed wholly or in part of Archæan rocks.

2. This line corresponds with a great fault, on the east side of which Longmynd rocks dip easterly, and on the west Tremadoc shales dip westerly.

3. The prevailing rock-types are purple rhyolites at the north end of the chain, purple hornstone (or hälleflinta) in the middle, and purple and green hornstone (or hälleflinta), with some indurated grits, partly derived from a gneissic series, at the south.

4. The Precambrian age of these rocks is proved by their close lithological affinities with known Salopian types, and by the almost universal occurrence of fragments of the purple rhyolites in the Longmynd series. The strike, also, is usually more or less transverse to the strike of the Cambrian deposits.

5. The rocks of this axis belong exclusively to the younger of the two Salopian Archæan groups, no traces of granitoid or gneissic rocks, except as included fragments, having been detected.

## APPENDIX.

## NOTES upon some SPECIMENS of SHROPSHIRE ROCKS.

By Prof. T. G. BONNEY, M.A., F.R.S., Sec. G.S.

(55) *Lyd's Hole, Pontesbury*.—A rhyolite, with well-marked fluidal structure, much stained with ferrite and with occasional patches of opacite. The rock exhibits a devitrified structure, the crystallites in most parts assuming an acicular form, the majority no doubt being felspar; but some, of a pale golden colour, must be a different mineral, possibly a mica allied to sericite. There seems in parts a tendency to a microspherulitic and even micrographic structure; the ferruginous constituents assume many forms, from mere specks to little rods and granules. There are two or three larger crystals of felspar, containing apparently glass inclusions; the fluidal bands are crossed transversely by a much more deeply stained zone. The rock has a general similarity to those common in the neighbourhood of the Wrekin.

(56) *Pontesford Hill, North-End Quarry*.—A remarkably beautiful specimen. The slide gives a complete section of an elongated cavity filled with chalcedony. The enclosing border of rock is a rhyolite; this has a fluidal structure parallel to the longer axis of the concretion, is deeply stained with ferrite, and exhibits in its crystallites indications of radial structure normal to the longer axis; within this is a zone of chalcedony, sometimes containing fragments of the rhyolite, the microliths of quartz being grouped in radiating tufts like the hairs in a sable-brush, a familiar appearance in agates: in places also they form regular spherulites; within this is an enclosure of minutely crystalline quartz. These hollow spherulitic concretions, subsequently partially or wholly filled by infiltrated minerals, are not uncommon in acid lavas; and I have been for some time engaged upon the study of a somewhat similar group from North Wales. The rock of Lea Hill, in the Wrekin district, is very similar in structure to this one from Pontesford Hill.

(57) *Pontesford Hill (summit)*.—The ground-mass is full of elongated microliths of felspar with a slightly parallel grouping, generally plagioclase, but possibly in one or two cases orthoclase, with dark granules, probably in many cases hæmatite, and numerous grains (generally rather irregular in outline) of augite. One of more definite form is a compound crystal about .02 inch in diameter. There is a small quantity of a chloritic mineral. The rock is a basalt, and more resembles that of a flow than of a dyke.

(58) *North of Lyd's Hole, Block in Caradoc Shale*.—The structure of this rock is a little abnormal. With ordinary light it exhibits a clear base containing a multitude of dark specks, evidently ferruginous, some being brown (probably the hydrous peroxide of iron) others nearly black. These are so arranged as to give a spotted aspect to the slide. On using crossed Nicols the spots containing the latter prove to be devitrified patches of one or more crystals, very imperfectly developed.

The browner spots remain dark, but contain many extremely minute (felspar?) microliths. In places the devitrified structure occupies the whole of irregular zones in the slide; in others there is a considerable amount left of the apparently unaltered base. This closely resembles a fluidal structure. On the whole, therefore, I consider this a fragment of rhyolitic lava, parts of which may still remain in a glassy state.

(59) *West of Gatten Lodge*.—A sedimentary rock, with the structure characteristic of the argillites or whetstones which occur in parts of Charnwood Forest, the rock being made up of innumerable minute granules, probably of quartz, and specks of ferrite. Larger fragments are also present: some resemble bits of a rather similar rock; others may be only patches where the staining is more pronounced; many are quartz, subangular in form; and two or three much resemble bits of rhyolite.

(60) *North end of Knolls Ridge*.—A rather coarsely crystalline rock, consisting to a large extent of a plagioclastic felspar. This is evidently decomposed; and the crystals enclose numerous microliths of epidote (of secondary formation); some exhibit a micrographic structure with quartz, such as is common in the syenites of Charnwood Forest. Grains of viridite are also enclosed. Larger patches of viridite are present, though not numerous, with a little quartz (this has more resemblance to an original constituent), some ilmenite and perhaps magnetite, and some apatite. Under the circumstances it is difficult to decide whether the rock should be called a diorite or a diabase; perhaps the former name is the safer, though it is by no means a typical example.

(61) *West of Linley Hall*.—In parts of this slide a very decided fragmental structure is visible. In these older rocks it is necessary to be always on one's guard to avoid mistaking the result of brecciation *in situ* (due to crushing, especially near faults) for an original elastic structure. I think, however, that there is here sufficient evidence of the latter. Minute crystals of epidote are not unfrequent, especially in the intervals between the apparent fragments. With ordinary light the ground-mass is clear and contains numerous specks of filmy golden-green mineral, and clotted spots of a dusty-grey or brownish mineral: part of the former is epidote; but some may be a variety of mica or chlorite, or possibly hornblende. With crossed Nicols the ground-mass exhibits a very minute devitrified structure. In this respect it has (except that distinct crystals of quartz or felspar are absent) a remarkable resemblance to some of the rocks from the Sharpley and Bardou districts in Charnwood Forest, especially to the more compact felstone-like varieties of the latter\*. I am disposed therefore to regard it as, like these, an indurated somewhat altered tuff.

\* Quart. Journ. Geol. Soc. vol. xxxiv. p. 209, vol. xxxvi. pp. 341-347.

## DISCUSSION.

The PRESIDENT said that Dr. Callaway's views would much alter the stratigraphy of the deep valley between the Longmynd and Stiper Stones. He had no doubt Tremadoc rocks were in that valley; whether the Stiper Stones were Upper Tremadoc or Arenig, and whether contemporaneous with the white grit of North Wales, was a dubious question; he invited discussion.

Dr. HICKS said he had but slightly examined the district. The paper was an important one. There appeared to be evidence of Precambrian rocks in contact with admitted Cambrian rocks; so that in this region also, as in the Welsh areas, we had a base-line. The paper was important also as showing that certain types of rocks were characteristic of the Precambrian groups over wide areas. Some years since he had expressed the view that the Stiper Stones were of Arenig age and about the horizon of the Grit-band of Caernarvonshire mentioned by the President.

Mr. RUTLEY said it struck him as possible that these rhyolite rocks occurred on the horizon of the Bala limestone. Also Mr. Allport had suggested that perlitic rocks, associated with beds mapped by the Geological Survey as Caradoc, were Precambrian. He thought it worth reconsidering whether these might not be really of Bala or Llandeilo age. The fragments might constitute old volcanic breccias or tuffs.

Prof. BONNEY said that the rocks of the Wrekin were certainly agglomerates, and that fragments of the rhyolite certainly occurred in the so-called Wrekin quartzites, which he believed were now admitted to underlie Tremadoc rocks. Hence they could not be of Bala age.

Dr. CALLAWAY said that he proposed on a future occasion to give more detailed sections of the country. As for Mr. Rutley's suggestion;—over the quartzite, which contained rhyolite fragments, was Hollybush sandstone, and over that, Tremadoc; further, rhyolitic fragments occurred in the conglomerate of the Longmynd, and even in the finer beds; so he thought the Archæan age of the rhyolites was proved beyond all question.